Macedonian Journal of Animal Science, Vol. **14**, No. 1–2, pp. 5–10 (2025)
Article 297
In print: ISSN 1857 – 6907
Received: October 33, 2025
On line: ISSN 1857 – 7709
Accepted: December 2, 2025
UDC: 639.31.043:579.551.2]:633.826
https://www.doi.org/10.54865/mjas25141-205m

Original scientific paper

DIETARY SUPPLEMENTATION WITH TURMERIC POWDER: IMPACT ON FEED CONVERSION RATIO IN CAGE-CULTURED COMMON CARP *(CYPRINUS CARPIO)*

Irina Manevska[1*], Marija Kostova[2], Vasil Kostov[1]

[1]*Institute of Animal and Fishery Science, Ss. Cyril and Methodius University in Skopje, Blvd. Ilinden 92a, 1000 Skopje, North Macedonia*
[2]*Bachelor of Ecology and Environmental studies, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University in Skopje, st. Arhimedova 3, 1000 Skopje, North Macedonia*
inst.stoc.manevska@gmail.com

A b s t r a c t: This study investigated the effect of dietary supplementation with turmeric powder (*Curcuma longa* L.) on the feed conversion ratio (FCR) of common carp (*Cyprinus carpio*) reared in an intensive cage system. The experiment lasted 92 days and included two groups: K5 (feed supplemented with 2% turmeric powder per kg) and K8 (control group, commercial feed without additives). FCR was monitored across three control measurements. The results showed that carp fed with the turmeric-supplemented diet (K5) achieved a consistently lower mean FCR compared to the control group (K8), indicating improved feed utilization efficiency. The biological trend clearly demonstrated the beneficial impact of turmeric on feed conversion. These findings suggest that turmeric acts as an effective natural phytogenic additive capable of enhancing feed efficiency and potential factor sustainable carp production.

Key words: *Curcuma longa*; common carp; feed conversion ratio; phytogenic additives; intensive cage system

ДОДАВАЊЕ НА КУРКУМА ВО ИСХРАНАТА: ВЛИЈАНИЕ ВРЗ КОНВЕРЗИЈАТА НА ХРАНА КАЈ КАФЕЗНО ОДГЛЕДУВАН КРАП (*CYPRINUS CARPIO*)

А п с т р а к т: Целта на ова истражување беше да се одреди влијанието на додатокот на куркума во прав (*Curcuma longa L.*) во храната, врз конверзијата на храна (FCR) кај крап (*Cyprinus carpio*) одгледуван во интензивен кафезен систем. Експериментот траеше 92 дена и опфати две групи: K5 (храна дополнета со 2% куркума во прав на килограм) и K8 (контролна група, комерцијална храна без адитиви). Конверзијата на храна беше следена во текот на три контролни мерења. Резултатите покажаа дека крапот хранет со храна дополнета со куркума (K5) постигна пониска средна вредност на FCR во споредба со контролната група (K8), што укажува на подобра ефикасност во искористувањето на храната. Биолошкиот тренд јасно го потврди позитивното влијание на куркумата врз конверзијата на храната. Резултатите укажуваат дека куркумата делува како ефикасен природен фитоген адитив, што може да ја подобри искористливоста на храната и е потенцијален фактор за одржливо производство на крап.

Клучни зборови: *Curcuma longa*; крап; конверзија на храна; фитогени адитиви; кафезен систем

INTRODUCTION

Feed management is one of the most crucial aspects of aquaculture, as feed costs typically represent between 50% and 70% of the total operational expenses in intensive fish farming systems (Tacon & Metian, 2015). Therefore, the efficient utilization of feed directly influences the profitability, sustainability, and ecological footprint of aquaculture operations (Manevska et al., 2025d). The feed

conversion ratio (FCR) is a key indicator of this efficiency, expressing the relationship between the amount of feed provided and the corresponding body weight gain of fish (De Silva & Anderson, 1995). A lower FCR value indicates more effective feed utilization and, consequently, better conversion of nutrients into fish biomass. Improving FCR not only enhances economic performance but also reduces waste output, nutrient loading, and the environmental impact of aquaculture systems (Bureau et al., 2003; Naylor et al., 2021; Manevska et al., 2024a).

In intensive cage systems, fish are typically exposed to higher levels of environmental and physiological stress due to limited water exchange, high stocking densities, and restricted access to natural food resources (Kestemont et al., 2007; Manevska et al., 2024b). These conditions can negatively influence feeding efficiency and growth performance. As a result, there is an increasing interest in the use of functional feed additives that can improve digestion, nutrient assimilation, and overall feed utilization (Citarasu, 2010; Chakraborty et al., 2014 Manevska et al., 2024c). Among these additives, phytogenic compounds – natural bioactive substances derived from plants – have gained particular attention as eco-friendly alternatives to antibiotics and synthetic growth promoters (Bulfon et al., 2013).

Turmeric (*Curcuma longa* Linn.), a rhizomatous herb belonging to the Zingiberaceae family, has been widely used in traditional medicine and, more recently, in animal nutrition due to its diverse biological properties. Its main active component, curcumin, along with demethoxycurcumin and bisdemethoxycurcumin, exhibits potent antioxidant, antiinflammatory, and antimicrobial activities (Prasad & Aggarwal, 2011; Gupta et al., 2013). These properties make turmeric a promising additive in aquafeeds to support growth performance, enhance feed efficiency, and strengthen immune responses (Abdel-Tawwab et al., 2018; Dawood et al., 2020).

Several studies have confirmed that the inclusion of turmeric powder or curcumin extract in fish diets can improve digestive enzyme activity, leading to enhanced nutrient digestibility and better FCR values. For instance, Abdel-Tawwab et al. (2018) reported that Nile tilapia (*Oreochromis niloticus*) fed turmeric-supplemented diets exhibited significantly improved feed utilization and antioxidant capacity. Similarly, Ahmadifar et al. (2021) observed that turmeric supplementation in the diet of rainbow trout (*Oncorhynchus mykiss*) reduced FCR and promoted immune modulation. These improvements are often attributed to curcumin's ability to stimulate bile secretion, enhance lipid and protein metabolism, and protect the intestinal mucosa from oxidative damage (Ravindran et al., 2007; Hasan & Banerjee, 2020).

The common carp (*Cyprinus carpio*), as one of the most widely cultured freshwater fish species worldwide, plays a significant role in global aquaculture production (FAO, 2022). Its omnivorous feeding behavior and adaptability to a variety of environmental and nutritional conditions make it a suitable model species for nutritional studies. However, in intensive cage culture systems, such as those practiced in reservoirs and lakes achieving optimal FCR remains challenging due to high fish densities and fluctuating water parameters. Thus, strategies that improve feed efficiency, such as the dietary inclusion of plant-based additives, are of particular interest for sustainable production systems (El-Haroun et al., 2006).

The present study focuses on evaluating the effects of turmeric powder supplementation in the diet of common carp reared in an intensive cage system. Specifically, it investigates whether the addition of turmeric can lead to a reduction in the feed conversion ratio (FCR), thereby enhancing production efficiency and sustainability. Understanding how such natural additives influence feed utilization not only contributes to more cost-effective farming but also supports environmentally responsible aquaculture practices and improving the overall health and resilience of cultured fish.

MATERIALS AND METHODS

The study was carried out at *MIA ECOFISH* a cage aquaculture facility located in the Kozjak reservoir. For the purpose of the experiment, two floating cages were selected, each measuring 5 × 5 × 5 m, with a total volume of 125 m³.

The trial commenced in May once the water temperature exceeded 15°C, when beginning of the active feeding period for common carp was started. Prior to stocking, the fish were graded to achieve uniformity. Two experimental groups with comparable starting biomass were established as presented in Table 1:

Turmeric (*Curcuma longa*) powder was provided by *Kibela LLC*, Skopje.

To prepare the experimental diet, commercial pelleted carp feed was enriched with 2% turmeric powder per kilogram. The powdered additive was

first dissolved in distilled water and subsequently mixed with the feed in an industrial blender for 10 minutes. The supplemented feed was then dried and stored at plastic cans until use

Table 1.

Initial experimental groups set up (number of fish per group, average weight and start biomass)

Group	Diet	Number of fish	Average weight (g)	Initial biomass (kg)
K5	Turmeric powder 2%/kg feed	275	319	90.0
K8	Control (commercial feed)	275	322	90.1

After stocking, fish were fed by feeders in accordance with the manufacturer's recommendations and adjusted to water temperature. Monthly sampling was performed to determine total biomass and the number of individuals per cage.

Feed conversion ratio (FCR) data obtained from the two experimental groups were statistically analyzed to determine the effects of dietary treatments on feed utilization efficiency in common carp (*Cyprinus carpio*). Each treatment group was represented by three measurement intervals (n = 3), corresponding to consecutive feeding and sampling periods during the 92-day experiment. All data were expressed as mean ± standard deviation (SD).

Before analysis, data were tested for normality (Shapiro-Wilk test) and homogeneity of variances (Levene's test). Differences among treatments K5 (turmeric 2%), and K8 (control) – were examined using a one-way analysis of variance (ANOVA). When the ANOVA indicated significant effects ($p< 0.05$), Tukey's HSD (honestly significantence) post hoc test was applied to determine pairwise differences among groups. Statistical significance was accepted at the level of $p < 0.05$.

RESULTS AND DISCUSSION

Feed conversion ratio (FCR) is a fundamental production parameter in aquaculture that reflects the efficiency of feed utilization. Lower FCR values correspond to better conversion of feed nutrients into fish biomass, representing improved production efficiency and sustainability (Tacon & Metian, 2015).

The results revealed clear differences between treatments. The group fed with turmeric (K5) demonstrated lower FCR values across all three measurement periods (1.27, 1.45, and 1.50) compared to the control group (1.65, 1.78, and 2.04, respectively). The mean FCR was 1.41 ± 0.12 in the turmeric-supplemented group, while it reached 1.82 ± 0.20 in the control group. This represents a reduction of approximately 22.5% in feed conversion ratio due to the inclusion of turmeric powder in the diet.

The statistical analysis (independent samples t-test) showed that the difference in FCR between the two groups was not statistically significant (t = – 2.03; p = 0.0887) at the 0.05 level (Table 2). However, the biological relevance of the trend is evident: carp fed with turmeric exhibited improved feed efficiency throughout the trial (Figure 1). Such improvement, even if not significant under the experimental conditions, can be considered economically and physiologically meaningful in aquaculture practice, where small reductions in FCR translate into substantial feed cost savings.

Table 2.

FCR average, Mean values (Mean) standard deviations (SD) and significance among treatments

Group	Control 1	Control 2	Control 3	Mean ± SD	Significance (p)
K5 (2% turmeric)	1.27	1.45	1.50	1.41 ± 0.12	
K8 (Control)	1.65	1.78	2.04	1.82 ± 0.20	
					t = –2.03; p = 0.0887, ns (p > 0.05)

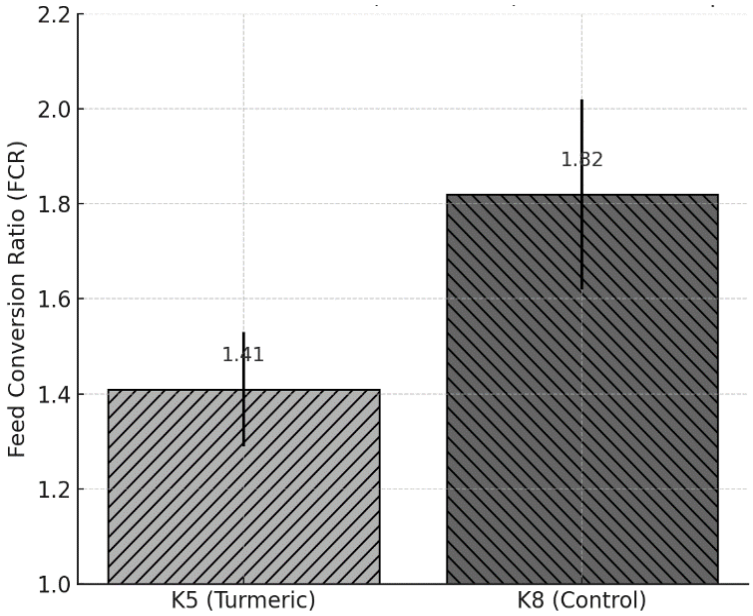

Fig. 1. Feed Conversion Ratio (Mean ± SD) in common carp fed with turmeric-supplemented (K5) and control (K8) diets

This suggests that, with a larger number of measurements or an extended experimental duration, the difference could reach statistical significance, highlighting the positive potential of turmeric in enhancing feed conversion efficiency in common carp.s

The observed improvement in feed conversion in the turmeric group may be attributed to the bioactive compounds present in turmeric, primarily curcumin, demethoxycurcumin, and bisdemethoxycurcumin. This aligns with findings from Fernández-Lázaro et al. (2020) and Yonar et al. (2019), who reported that turmeric inclusion enhances antioxidant enzyme activity and immune function, leading to better growth efficiency. Furthermore, turmeric possesses antioxidant and anti-inflammatory properties that can improve metabolic efficiency and reduce oxidative stress, thus contributing to better feed utilization and growth.

Similar findings have been reported in previous studies on carps and other freshwater species. Yonar et al. (2019) found that dietary turmeric supplementation at 1–3% improved feed conversion and growth in common carp and Nile tilapia, while Fernández-Lázaro et al. (2020) highlighted curcumin's role in enhancing intestinal morphology and nutrient uptake. In the present experiment, the direction and magnitude of the FCR reduction are consistent with these reports, confirming the positive influence of turmeric on nutrient assimilation and growth performance under intensive rearing conditions. Results reported by Abdel-Tawwab et al. (2018) and Mahmoud et al. (2023), who observed that turmeric-supplemented diets (1–2%) significantly improved feed efficiency, protein retention, and growth rate in *Cyprinus carpio* and *Oreochromis niloticus*. These improvements are attributed to the bioactive compound curcumin, which stimulates digestive enzyme secretion, improves hepatic lipid metabolism, and reduces oxidative damage in intestinal tissues (Hewlings & Kalman, 2017; Dawood et al., 2020).

The biological impact of turmeric supplementation on feed conversion efficiency is clearly positive. The consistent reduction in FCR across all measurement periods supports the hypothesis that turmeric acts as a natural phytogenic enhancer of feed utilization in common carp. The results emphasize the potential of integrating such plant-based additives into practical aquafeeds as part of sustainable and environmentally responsible aquaculture strategies.

The mechanism underlying this improvement is linked to the antioxidant and anti-inflammatory activity of curcumin, which promotes intestinal health and optimizes gut microbiota composition (Hasan & Banerjee, 2020). By mitigating oxidative stress and enhancing nutrient absorption, curcumin supports more efficient energy utilization and growth. Furthermore, the lower FCR observed in the turmeric group may indicate better resilience to environmental and metabolic stressors typical of intensive cage systems. Thus, the obtained results suggest that turmeric, even at a low inclusion rate of

1%, can serve as a sustainable and biologically active supplement to improve feed conversion and promote fish welfare in intensive carp aquaculture.

Variations in FCR could be attributed to differences in environmental factors such as temperature, dissolved oxygen, or feeding activity, which directly influence metabolic rate and feed intake in fish (De Silva & Anderson, 1995; Dawood et al., 2020). The final average FCR value in this group suggests that dietary supplementation, potentially including turmeric, may contribute to maintaining effective feed utilization compared to the control group, as previously reported in similar studies on common carp and other freshwater species (Abdel-Tawwab et al., 2018; Dawood et al., 2020 and Ahmadifar et al., 2021).

Curcumin has been shown to stimulate bile secretion, increase nutrient absorption, and promote antioxidant defense mechanisms, thereby reducing oxidative stress in fish intestines (Hasan & Banerjee, 2020). These effects collectively enhance the efficiency of nutrient metabolism and result in a lower FCR. Similar findings were reported by Ahmadifar et al. (2021), where curcumin-supplemented diets improved feed efficiency and growth performance in rainbow trout and tilapia.

Overall, turmeric powder demonstrated positive effects on feed conversion, confirming potential as functional feed additives in common carp diets. These results align with previous studies emphasizing the benefits of plant-based additives for improving feed efficiency and promoting sustainable aquaculture practices (Citarasu, 2010; Chakraborty et al., 2014; Dawood et al., 2020; Dawood et al., 2021; Patra et al., 2022).

CONCLUSION

In accordance with recent literature, the findings demonstrate that turmeric powder can enhance feed utilization in common carp. The positive trend in K5 confirms curcumin's metabolic potential. The results support the hypothesis that natural plant-based additives can be effective, sustainable alternatives to synthetic growth promoters in aquaculture production.

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